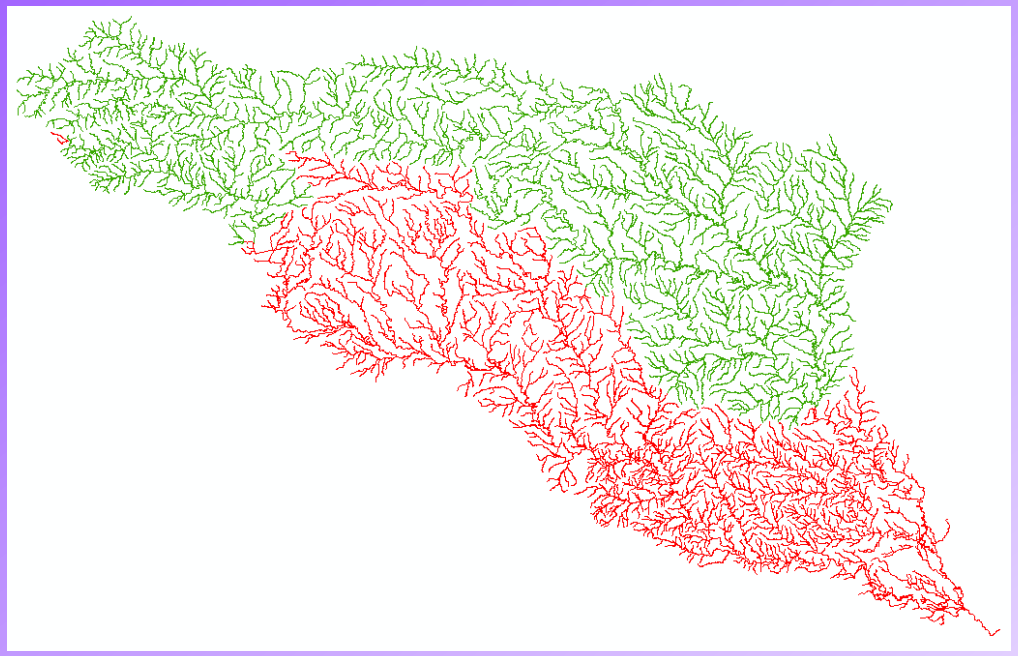
# Parallel Computing in RAPID



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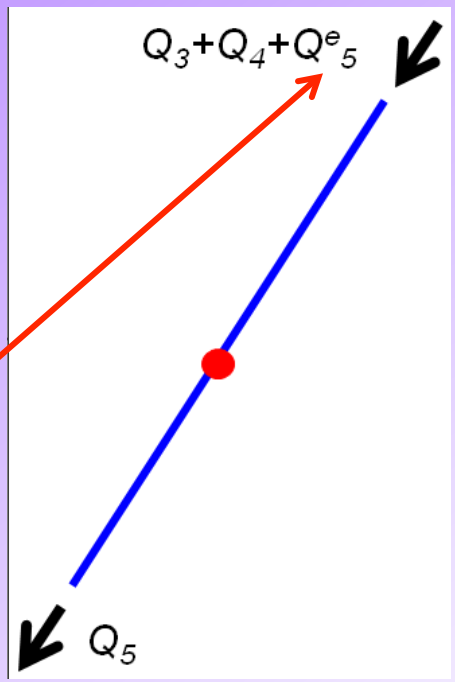
# Muskingum method applied to one river reach

Outflow(t+Δt) Inflow(t+Δt)

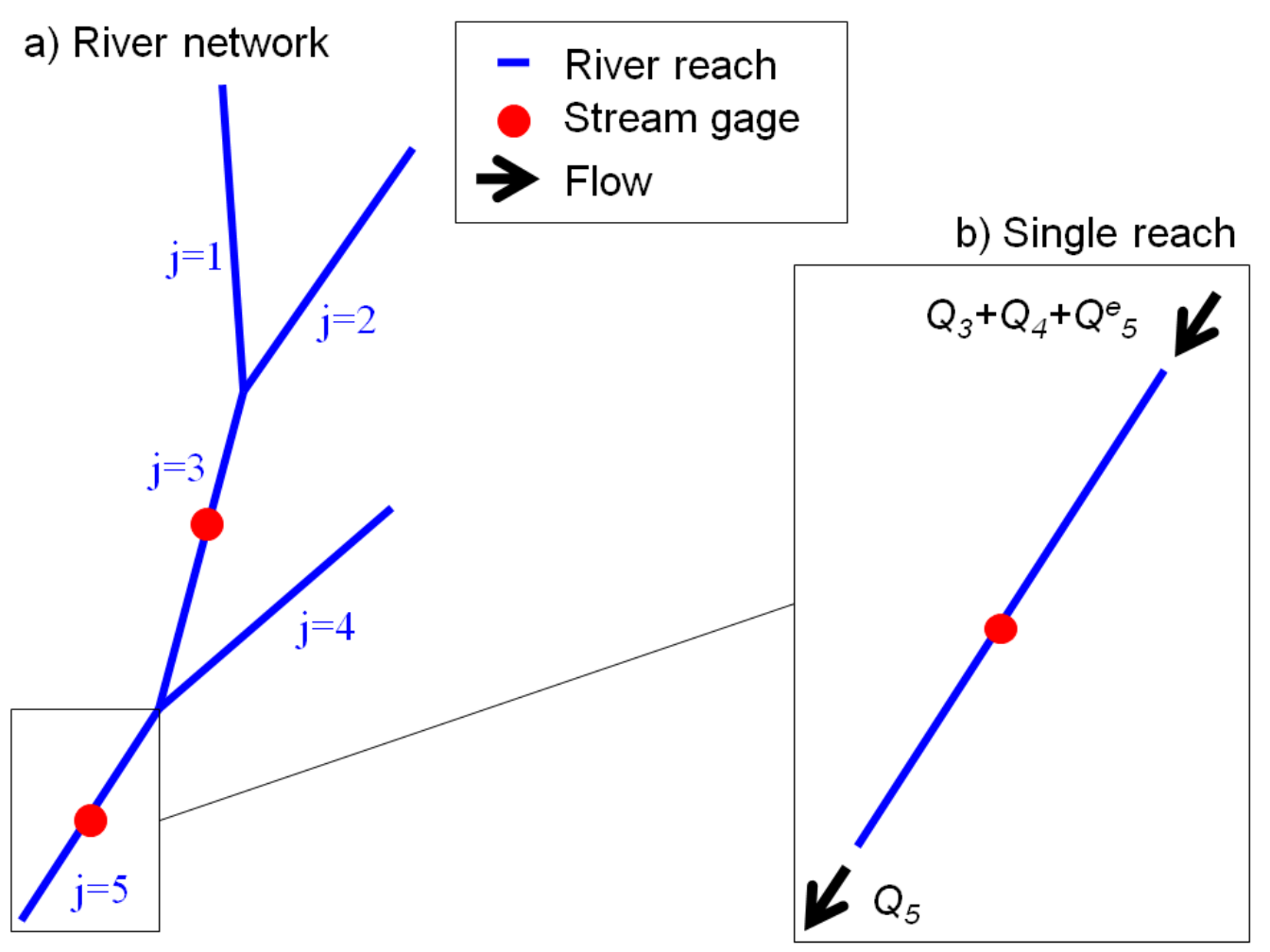
$$Q_5(t+\Delta t) = C_{1_5} \cdot \left[Q_3(t+\Delta t) + Q_4(t+\Delta t) + Q^e{}_5(t)\right]$$
$$+ C_{2_5} \cdot \left[Q_3(t) + Q_4(t) + Q^e{}_5(t)\right]$$
$$+ C_{3_5} \cdot Q_5(t)$$

Inflow(t) Outflow(t)

Assumptions



# Conceptual river network



# Muskingum method applied to a river network in a matrix-based approach

Flows

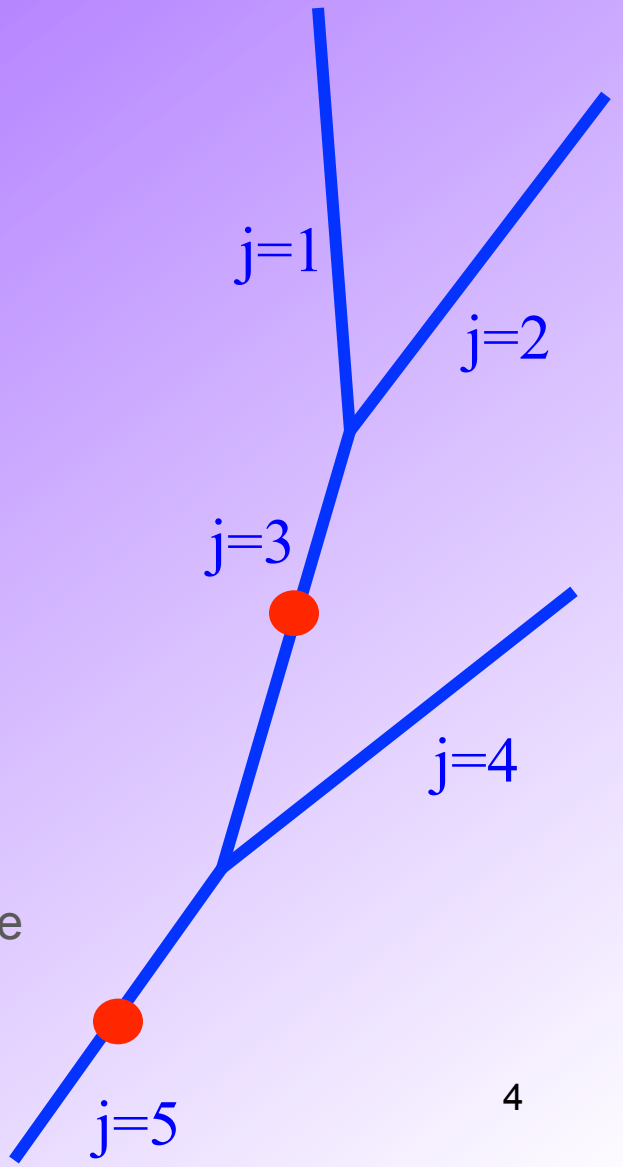
Lateral inflows

$$\left(\mathbf{I}-\mathbf{C}_1\cdot\mathbf{N}\right)\cdot\mathbf{Q}\left(t+\Delta t\right)=\mathbf{C}_1\cdot\mathbf{Q}^{\mathrm{e}}\left(t\right)$$
$$+\mathbf{C}_2\cdot\left(\mathbf{N}\cdot\mathbf{Q}\left(t\right)+\mathbf{Q}^{\mathrm{e}}\left(t\right)\right)$$
$$+\mathbf{C}_3\cdot\mathbf{Q}\left(t\right)$$
$$=\mathbf{b}\left(t\right)$$

Parameter matrices

Network matrix

Right-hand side




Simultaneous computation on entire river network

# Network and parameter matrices

$$\mathbf{Q} = \begin{bmatrix} Q_1 \\ Q_2 \\ Q_3 \\ Q_4 \\ Q_5 \end{bmatrix}$$

Vector of outflows

$$\mathbf{N} = \begin{bmatrix} & & & & \\ 1 & 1 & & & \\ & & & & \\ & & 1 & 1 & \end{bmatrix}$$

Network matrix
$N_{i,j}$=1 if reach j flows into reach i

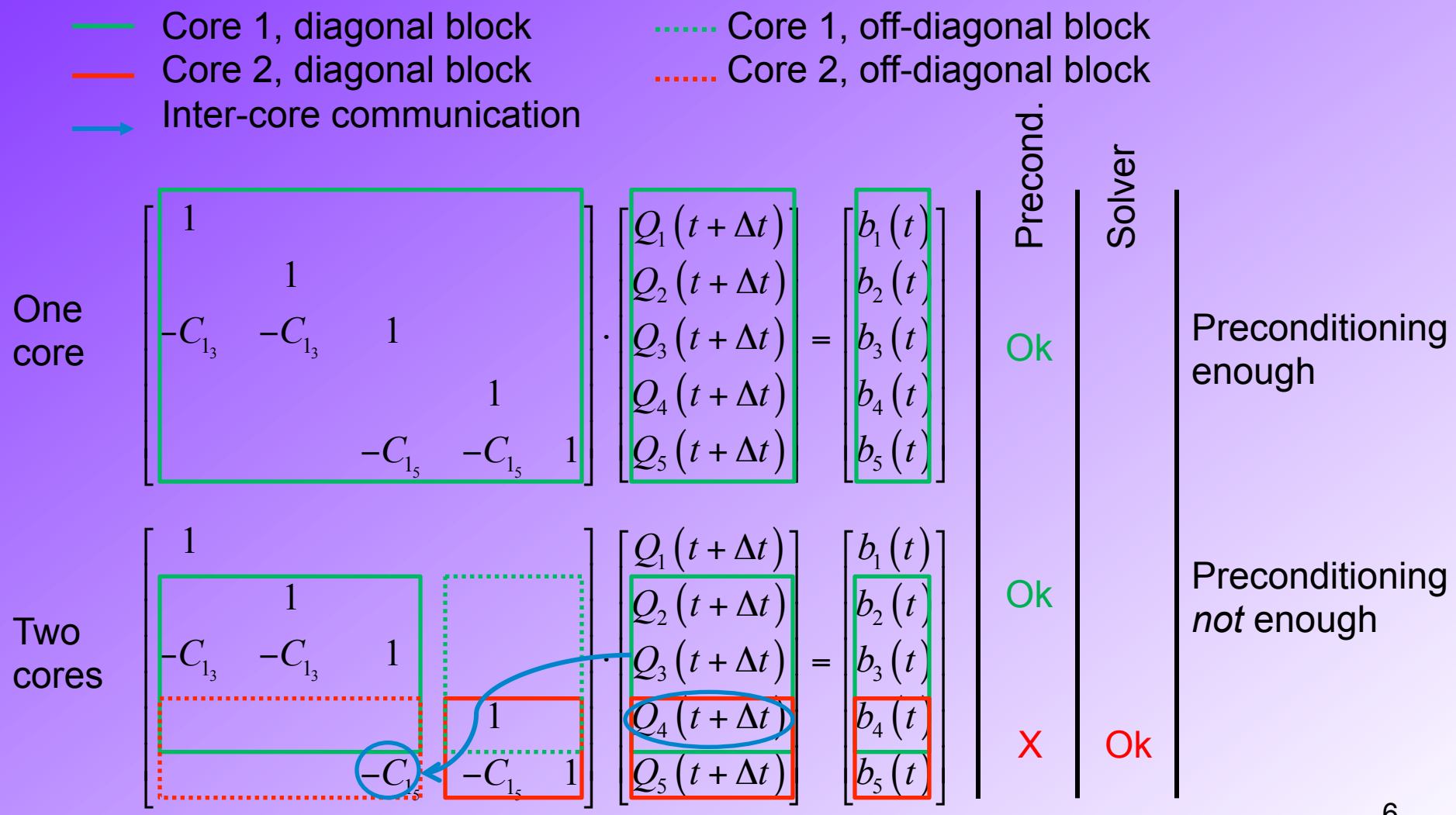
$$\mathbf{C_1} = \begin{bmatrix} C_{l_1} & & & & \\ & C_{l_2} & & & \\ & & C_{l_3} & & \\ & & & C_{l_4} & \\ & & & & C_{l_5} \end{bmatrix}$$

Parameter matrix

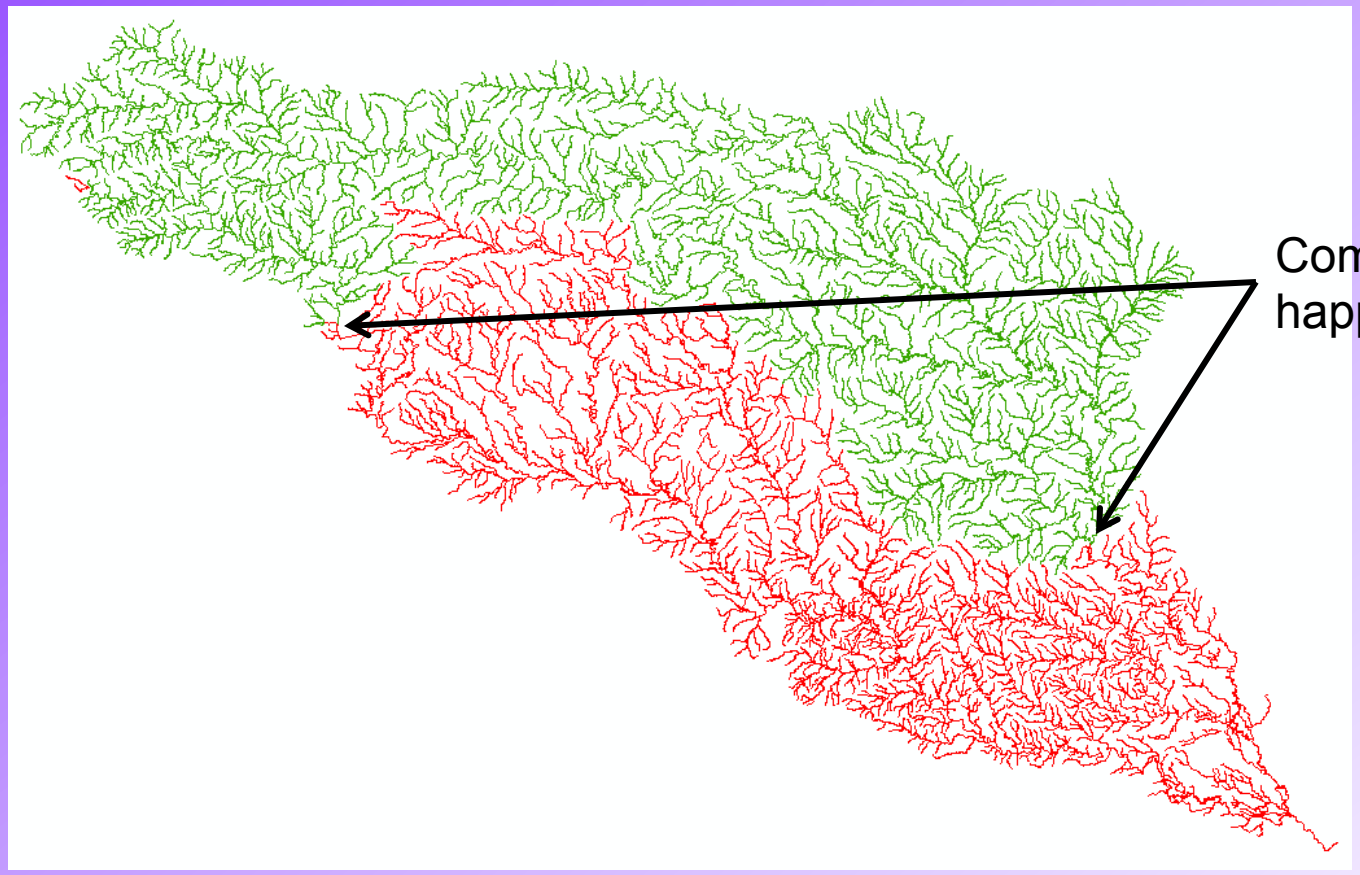
$$\mathbf{I} - \mathbf{C_1} \cdot \mathbf{N} = \begin{bmatrix} 1 & & & & \\ & 1 & & & \\ -C_{l_3} & -C_{l_3} & 1 & & \\ & & & 1 & \\ & & & -C_{l_5} & -C_{l_5} & 1 \end{bmatrix}$$

Linear system matrix

# How to solve this linear system on multiple cores?



# Example for San Antonio and Guadalupe Basins in Texas




When river reaches are ordered with decreasing Hydroseq

# Further information

RAPID website: http://rapid-hub.org/

RAPID source code: https://github.com/c-h-david/rapid/